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# A METHOD AND APPARATUS FOR HEATING A MOTOR VEHICLE CABIN

The present invention relates to a method and apparatus for heating a motor vehicle cabin.

In motor vehicles, the engine includes a circuit for circulating a cooling fluid which is used for cooling the engine and also for heating the cabin. To this end, the circuit includes in particular a pump and an air heater unit through which air is caused to flow to pick up heat stored in the cooling fluid for the purpose of heating the cabin.

However, in certain circumstances, and more particularly during the first few minutes of operation of the vehicle, or when the weather is particularly cold, such heater apparatus is not sufficient.

In order to improve cabin heating quickly, several techniques are presently in use.

One of those techniques consists in using electrical resistance elements, sometimes in the water circuit, but more generally in the air circuit. Another technique consists in using burners.

However those techniques give rise to problems of siting and they increase the cost of the vehicle. Furthermore, they lead to excess consumption and a non-negligible expenditure of energy, and when burners are used they also lead to odors and smoke.

Yet another technique consists in placing a heat exchanger in the exhaust system of the vehicle, upstream from a depollution unit, which heat exchanger is integrated in the circuit for circulating the engine's cooling fluid. Heat recovered from the exhaust gas in this way can thus serve to heat the vehicle cabin indirectly.

That disposition presents drawbacks lying mainly in the fact that it requires exhaust gas to flow slowly through the depollution assembly constituted by catalysts while the temperature of the engine is rising, i.e. when starting, in order to ensure that the depollution

assembly reaches its optimum operating temperature quickly.

Consequently, during the starting stage, no additional heat energy is recovered for heating the  
5 cabin.

An object of the invention is to solve those problems and to improve cabin heating performance.

The invention thus provides a method of heating a motor vehicle cabin by means of a circuit for circulating  
10 a cooling fluid for cooling an engine and including a pump, an air heater unit, and a heat exchanger disposed in an exhaust system that is also provided with a depollution assembly, the method being characterized in that the exhaust gas in the exhaust system and downstream  
15 from the depollution assembly is directed towards said heat exchanger or towards a bypass duct as a function of engine operating conditions, of the outside temperature, of the heating temperature requested in the cabin, and of the temperature of the engine cooling fluid.

20 The invention also provides apparatus for heating a motor vehicle cabin, the apparatus being of the type comprising a circuit for circulating a cooling fluid for cooling an engine and including a pump, an air heater unit, and a heat exchanger disposed in an exhaust system  
25 provided with a depollution assembly, the apparatus being characterized in that the heat exchanger is placed in said exhaust system downstream from the depollution assembly in the exhaust gas flow direction, and in that it includes a flap for directing the exhaust gas either  
30 towards the heat exchanger or towards a bypass duct, said flap being actuated by control means as a function of the operating conditions of the engine, of the outside temperature and of the heating temperature requested in the cabin and of the temperature of the engine cooling  
35 fluid.

The invention can be better understood on reading the following description given by way of example and

made with reference to the accompanying drawings, in which:

• Figure 1 is a diagram of an engine and its exhaust system fitted with cabin heater apparatus in accordance  
5 with the invention; and

• Figure 2 is a curve plotting heat energy recovery from the exhaust system as a function of the temperature of the engine cooling fluid and as a function of time.

Figure 1 is a diagram showing an engine 10, e.g. a  
10 direct injection diesel engine, which, in conventional manner, has injectors 11 fed with fuel by a circuit 12 including a high pressure pump 13. The injection of fuel by the injectors 11 into the cylinders of the engine 10 is controlled by means of a controller 1 connected to  
15 each injector 11 via an electrical circuit 2.

The engine 10 also has an exhaust system given overall reference 15 that is provided with a depollution assembly 16 constituted by a catalyst and a particle filter, for example.

20 Downstream from the depollution assembly 16 in the exhaust gas flow direction, as shown by arrow F in the exhaust system 15, there are provided first and second passages 17 and 18 for the exhaust gas.

As shown in Figure 1, the first passage 17 in the  
25 exhaust system 15 is fitted with a heat exchanger 21 for exchanging heat with a circuit 20 for circulating a cooling fluid for the engine 10, which circuit also includes an air heater unit 22 and a water pump 23. In conventional manner, a flow of air passes through the air  
30 heater unit 22 so as to recover heat stored in the cooling fluid circulating round the circuit 20, thereby serving to heat the cabin of the motor vehicle.

The exhaust gas is caused to flow through the first passage 17 or through the second passage 18 under the  
35 control of a flap 25 that is movable by means of an actuator 26, e.g. constituted by an electric motor, between a first position for closing the second passage

18, as shown in Figure 1, and in which all of the exhaust gas flows along the first passage 17 through the heat exchanger 21, and a second position in which the flap closes the first passage 17 and in which it allows all of the exhaust gas to flow through the second passage 18, which then constitutes a bypass duct.

The actuator 26 is connected to the controller 1.

The flap 25 is tilted between its two positions in the flow direction of the gas in the exhaust system 15.

As shown in Figure 1, the flap 25 is preferably disposed downstream from the heat exchanger 1 relative to the flow direction of the gas in the exhaust system 15.

Furthermore, the engine 10 includes means for injecting an additional quantity of fuel into at least some of the cylinders of said engine after the main injection of fuel therein and during the expansion stage of the cycle of these cylinders, so as to give rise to additional combustion of fuel and increase the temperature of the exhaust gas flowing in particular through the heat exchanger 21.

The controller can respond to various parameters such as the temperature of the cooling fluid for the engine 10, the outside temperature, a requested level for heating in the cabin, engine revolutions, and/or the load on the engine in order to adjust strategies for controlling the injectors 11 so as to change the way the energy budget of the fuel consumed is shared so that during starting stages when the heating power available for heating the cabin is insufficient, the amount of energy transferred to the walls of the engine is increased, thereby increasing the energy transferred to the circuit 20 for circulating the cooling fluid, and also increasing the energy transferred to the gas flowing in the exhaust system 15, i.e. through the depollution assembly 16 and the heat exchanger 21.

The system for heating the vehicle cabin is generally put into operation when the outside air temperature is less than 10°C.

5 The operating conditions of the engine 10 that are taken into account by the method of the invention are the torque and/or the speed of rotation of said engine.

In the method of the invention several strategies can be devised for recovering thermal energy from the exhaust (RTE) alone or in combination with injecting an  
10 additional quantity of fuel (PI) into at least some of the cylinders of said engine 10.

In general, the exhaust gas is directed to the heat exchanger 21 in order to recover thermal energy from the exhaust (RTE) without additional fuel injection (PI) into  
15 some of the cylinders for a determined maximum speed of rotation lying in the range 2500 revolutions per minute (rpm) to 3500 rpm, and/or for torque less than a determined maximum torque lying in the range 100 newton meters (Nm) to 200 Nm.

20 Similarly, the exhaust gas is directed towards the heat exchanger 21 without additional injection of fuel when the temperature of the cooling fluid is below a temperature lying in the range 70°C to 85°C, and preferably below 80°C, while the outside temperature is  
25 less than a temperature lying in the range 5°C to 15°C, and preferably less than 10°C.

Furthermore, the exhaust gas is directed to the heat exchanger 21 in order to recover thermal energy from the exhaust (RTE) while simultaneously injecting additional  
30 fuel (PI) into some of the cylinders of the engine 10 for a determined maximum speed of rotation lying in the range 2500 rpm to 3500 rpm, and/or for a determined torque lying between a maximum torque and a minimum torque which are functions of the speed of rotation of said engine 10.

35 Similarly, the exhaust gas is directed to the heat exchanger 21 while simultaneously injecting additional fuel into some of the cylinders when the temperature of

the cooling fluid for the engine 10 lies between a minimum temperature lying in the range  $-5^{\circ}\text{C}$  to  $+5^{\circ}\text{C}$ , and preferably of the order of  $0^{\circ}\text{C}$ , and a maximum temperature lying in the range  $70^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ , and preferably of the order of  $80^{\circ}\text{C}$ , while the outside temperature is less than a temperature lying in the range  $5^{\circ}\text{C}$  to  $15^{\circ}\text{C}$ , and preferably of the order of  $10^{\circ}\text{C}$ .

With reference to Figure 2, there follows a description of one example of an operating strategy for the method of the invention.

By way of example, the vehicle cabin heating system is set into operation when the temperature of the outside air is less than  $10^{\circ}\text{C}$ .

When the vehicle is started cold, with an outside air temperature of less than  $10^{\circ}\text{C}$ , in order to make the cabin comfortable, the controller engages recovery of thermal energy from the exhaust (RTE) on its own, while the temperature of the cooling fluid in the circuit 20 is below  $0^{\circ}\text{C}$ .

While thermal energy is being recovered from the exhaust, the actuator 26 causes the flap 25 to take up its position in which it closes the bypass duct 18 so that all of the exhaust gas flows through the first passage 17 and consequently through the heat exchanger 21 so as to increase the temperature of the cooling fluid circulating in the circuit 20.

As shown in Figure 2, when the temperature of the cooling fluid for the engine 10 lies in the range  $0^{\circ}\text{C}$  to  $78^{\circ}\text{C}$ , the controller 1 actuates thermal energy recovery from the exhaust by causing all of the exhaust gas to pass through the heat exchanger 21, and also causes an additional quantity of fuel to be injected into at least some of the cylinders of the engine 10, thereby increasing the temperature of the exhaust gas flowing through the heat exchanger 21, thus providing additional heat for heating the cabin of the motor vehicle.

For a cooling fluid temperature lying in the range 78°C to 80°C, the controller 1 makes use solely of thermal energy recovery from the exhaust. This recovery of thermal energy from the exhaust is reengaged if the  
5 temperature of the cooling fluid of the engine drops below 78°C, as shown in Figure 2.

Finally, recovery of thermal energy from the exhaust together with the injection of an additional quantity of fuel are both reengaged if the temperature of the cooling  
10 fluid in the circuit 20 drops below 76°C.

The various strategies mentioned above are given purely by way of example and could naturally be modified.

While the exhaust gas is flowing through the heat exchanger 21, the exhaust gas also flows through the  
15 depollution assembly 16. Thus, during the starting stage, while thermal energy is being recovered from the exhaust to heat the cabin via the heat exchanger 21, the exhaust gas continues to flow through the depollution assembly 16, thereby enabling the temperature in the  
20 depollution assembly to rise quickly, so that it reaches its optimum operating temperature in a very short length of time.